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Path analysis of socio-economic impact of broad bed furrow technology among BBF adopters

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Abstract

Broad Bed Furrow (BBF) is an important climate-smart technology for improving the management of excess rainfall and soil moisture in soybean-based rainfed farming systems. The present study was undertaken to analyse the direct, indirect and total effects of selected characteristics of BBF adopters on the socio-economic impact of BBF technology. The study was conducted in Latur and Dharashiv districts of the Marathwada region of Maharashtra. A multistage sampling procedure was followed, and 150 soybean growers who had adopted BBF technology were selected from 30 villages. Data were collected through personal interviews using a pre-tested structured interview schedule and analysed using path analysis. The results revealed that area under soybean crop recorded the highest positive direct effect (0.320) on socio-economic impact, followed by annual income (0.224), land holding (0.184), attitude towards BBF technology (0.171), sources of information (0.160) and material possession (0.122). Area under BBF technology recorded a negative direct effect (-0.162) but showed the highest total indirect effect (0.797), indicating that its contribution was largely mediated through other variables. Land holding recorded the highest total effect (0.691), followed by annual income (0.668), area under soybean crop (0.657), area under BBF technology (0.635), material possession (0.522), sources of information (0.441) and social participation (0.429). Area under soybean crop, sources of information and attitude towards BBF technology emerged as important pathways through which several characteristics contributed indirectly to socio-economic impact. The findings indicate that farm resource base, economic status, extent of soybean cultivation, access to information and favourable attitude towards BBF technology were important factors associated with the socio-economic impact of BBF among adopters. Strengthening extension support, improving access to relevant information and encouraging favourable perceptions towards BBF technology may therefore help farmers realize greater socio-economic benefits from climate-smart soybean production.

Keywords: Broad bed furrow, climate-smart technology, soybean growers, socio-economic impact, path analysis, direct effect, indirect effect

Introduction

Indian agriculture is increasingly affected by climate variability, irregular rainfall, drought, soil erosion and water stagnation, particularly in rainfed farming areas. About 60.00 per cent of the net cultivated area in India is rainfed and remains vulnerable to climatic variability and abiotic stresses. Under such conditions, the use of climate-resilient agricultural technologies for better management of soil and water is important for maintaining agricultural productivity

(Department of Science and Technology, 2016) [2].

Soybean is an important oilseed crop in India and contributes substantially to the agricultural economy. However, its production and productivity have shown considerable fluctuations in recent years. Soybean productivity declined from 1,179 kg ha⁻¹ in 2024–25 to 1,028 kg ha⁻¹ in 2025–26, while production declined from 152.68 lakh tonnes to 127.20 lakh tonnes during the same period (Department of

Agriculture & Farmers Welfare [DA&FW]). Maharashtra is one of the major soybean-producing states, with 44.683 lakh ha under soybean cultivation, a productivity of 1,169 kg ha⁻¹ and estimated production of 52.229 lakh tonnes during Kharif 2025 (Soybean Processors Association of India [SOPA], 2025) [8].

In rainfed soybean production, Broad Bed Furrow (BBF) technology offers a suitable approach for managing excess rainfall as well as soil moisture. The technology improves drainage during periods of excess rainfall and helps retain soil moisture during dry spells. It also reduces runoff, soil erosion and nutrient losses, thereby supporting better crop growth and sustainable soybean production under rainfed conditions (Food and Agriculture Organization [FAO]) [3].

The benefits obtained from BBF technology may differ among farmers depending on their personal, socio-economic, communication and psychological characteristics. Factors such as education, landholding, annual income, social participation, sources of information and attitude towards BBF may influence the socio-economic impact of the technology. These factors may not act independently; some may have a direct influence on socio-economic impact, while others may contribute indirectly through their relationship with other variables.

Although BBF has considerable potential for improving soybean production under rainfed conditions, research specifically examining its adoption and impact among soybean growers in the Marathwada region of Maharashtra remains limited. Moreover, there is a need to understand the direct as well as indirect contribution of socio-economic, psychological and communication variables to the socio-economic impact of BBF. Path analysis is useful in this context as it helps to separate the direct, indirect and total effects of different variables.

Therefore, the present study was undertaken to analyse the direct, indirect and total effects of selected characteristics of BBF adopters on the socio-economic impact of Broad Bed Furrow technology.

Methodology

The study was carried out in the Marathwada region of Maharashtra. Latur and Dharashiv districts were purposively selected considering the area under soybean cultivation and the adoption of Broad Bed Furrow (BBF) technology. A multistage sampling procedure was followed for selecting the respondents. Three talukas from each district and five villages from each selected taluka were chosen. From each village, five soybean growers who had adopted BBF technology were selected, giving a total sample of 150 BBF adopters. An ex-post facto research design was used for the study (Kerlinger (2000)) [5]. Data were collected through personal interviews with the help of a pre-tested structured interview schedule. Information was collected on selected personal, socio-economic, communication and psychological characteristics of the BBF adopters, along with the socio-economic impact of BBF technology. Path analysis was used to determine the direct, indirect and total effects of the selected independent variables on the socio-economic impact of BBF technology among the adopters.

Results and Discussion

Path analysis is an extension of multiple regression analysis that is used to determine the magnitude and direction of both direct and indirect effects of independent variables on a dependent variable. It provides a better understanding of the relative importance of each variable by partitioning the correlation coefficients into direct and indirect effects. In the present study, path analysis was employed to assess the contribution of selected profile characteristics of soybean growers towards the socio-economic impact of climate smart technology-Broad Bed Furrow (BBF). The results presented in Table 1 explain the direct and indirect influence of the selected profile characteristics on the socio-economic impact of BBF technology. The effects are discussed under five components, namely total effect (TE), direct effect (DE), total indirect effect (TIE), first substantial indirect effect (SIE-I) and second substantial indirect effect (SIE-II), to identify the relative contribution of each variable towards the socio-economic impact of BBF technology.

Table 1: Direct, indirect and total effects of selected characteristics of BBF adopters on socio-economic impact of BBF technology (n = 150)

Sr. No.	Name of variable	TE	DE	TIE	SIE-1	SIE-2
X1	Farming experience	-0.098	-0.006	-0.093	-0.048 (X11)	-0.027 (X2)
X2	Education	0.218	0.051	0.167	0.058 (X11)	0.031 (X5)
X3	Occupation	0.142	-0.032	0.173	0.092 (X5)	0.076 (X7)
X4	Land holding	0.691	0.184	0.507	0.288 (X5)	0.209 (X7)
X5	Area under soybean crop	0.657	0.320	0.337	0.177 (X7)	0.166 (X4)
X6	Area under BBF technology	0.635	-0.162	0.797	0.309 (X5)	0.177 (X7)
X7	Annual income	0.668	0.224	0.444	0.252 (X5)	0.172 (X4)
X8	Material possession	0.522	0.122	0.400	0.144 (X5)	0.089 (X7)
X9	Social participation	0.429	0.058	0.372	0.135 (X5)	0.085 (X7)
X10	Extension contact	0.302	0.056	0.246	0.075 (X5)	0.057 (X11)
X11	Sources of information	0.441	0.160	0.280	0.063 (X15)	0.054 (X5)
X12	Innovativeness	0.302	0.043	0.259	0.081 (X5)	0.072 (X7)
X13	Economic motivation	0.275	0.053	0.222	0.057 (X15)	0.044 (X11)
X14	Risk orientation	0.318	0.021	0.296	0.066 (X15)	0.047 (X11)
X15	Attitude towards Broad Bed Furrow	0.381	0.171	0.210	0.059 (X11)	0.038 (X5)

1. Direct effect (DE)

The path analysis revealed that area under soybean crop (X5) had the highest positive direct effect (0.320) on the socio-economic impact of BBF technology. This suggests that farmers cultivating soybean on a larger area were likely to experience greater socio-economic benefits from BBF adoption. This finding is in accordance with Sharma *et al.* (2019)^[7], who reported important productivity and economic benefits associated with BBF seed-drill use in soybean cultivation. The next highest direct effects were observed for annual income (X7) (0.224), land holding (X4) (0.184), attitude towards BBF technology (X15) (0.171), sources of information (X11) (0.160) and material possession (X8) (0.122). These findings indicate that better resource availability, stronger economic conditions, access to information and a favourable attitude towards BBF were positively related to the socio-economic impact of the technology. Smaller positive direct effects were observed for social participation (X9) (0.058), extension contact (X10) (0.056), economic motivation (X13) (0.053), education (X2) (0.051), innovativeness (X12) (0.043) and risk orientation (X14) (0.021). In contrast, area under BBF technology (X6) (-0.162), occupation (X3) (-0.032) and farming experience (X1) (-0.006) showed negative direct effects. However, the positive total indirect effects of these variables indicate that their contribution to socio-economic impact was expressed mainly through their relationships with other variables in the path model.

2. Total indirect effect (TIE)

Area under BBF technology (X6) recorded the highest total indirect effect (0.797). A similar positive response to BBF technology was reported by Suryawanshi *et al.* (2026)^[9], who observed higher soybean yield, net returns and benefit-cost ratio under BBF compared with conventional flat sowing. Followed by land holding (X4) (0.507), annual income (X7) (0.444), material possession (X8) (0.400), social participation (X9) (0.372) and area under soybean crop (X5) (0.337). The remaining positive total indirect effects were observed for risk orientation (X14) (0.296), sources of information (X11) (0.280), innovativeness (X12) (0.259), extension contact (X10) (0.246), economic motivation (X13) (0.222), attitude towards BBF technology (X15) (0.210), occupation (X3) (0.173) and education (X2) (0.167). Farming experience (X1) recorded a negative total indirect effect (-0.093). The results show that several characteristics contributed to socio-economic impact through their relationships with other characteristics rather than through direct effects alone.

3. Total effect (TE)

When both direct and indirect effects were considered, land holding (X4) recorded the highest total effect (0.691), followed by annual income (X7) (0.668), area under soybean crop (X5) (0.657) and area under BBF technology (X6) (0.635). Material possession (X8) (0.522), sources of information (X11) (0.441), social participation (X9) (0.429) and attitude towards BBF technology (X15) (0.381) also showed comparatively higher total effects. Risk orientation (X14) recorded a total effect of 0.318, while extension contact (X10) and innovativeness (X12) each recorded 0.302.

Economic motivation (X13), education (X2) and occupation (X3) recorded total effects of 0.275, 0.218 and 0.142, respectively. Farming experience (X1) showed a negative total effect (-0.098). The higher total effects observed for land holding, annual income, area under soybean and area under BBF suggest that farm resources, production scale and economic position were important factors associated with the socio-economic impact of BBF technology.

4. Substantial indirect effect-I (SIE-I)

The substantial indirect pathways showed that area under soybean crop (X5) was an important pathway linking several characteristics with socio-economic impact. Area under BBF technology (X6) showed its highest substantial indirect effect through area under soybean crop (X5) (0.309), followed by land holding (X4) through X5 (0.288) and annual income (X7) through X5 (0.252). Material possession (X8), social participation (X9), extension contact (X10) and innovativeness (X12) also showed substantial indirect effects through area under soybean crop. Education (X2) and farming experience (X1) showed substantial indirect pathways through sources of information (X11). Sources of information (X11), economic motivation (X13) and risk orientation (X14) showed substantial indirect pathways through attitude towards BBF technology (X15). These findings indicate that area under soybean crop, sources of information and attitude towards BBF were important pathways through which several characteristics were related to the socio-economic impact of BBF technology.

5. Substantial indirect effect-II (SIE-II)

The second substantial indirect pathways further showed the role of annual income, land holding, area under soybean crop and sources of information. Land holding (X4) showed an indirect effect through annual income (X7) (0.209), while area under BBF technology (X6) showed an indirect effect through annual income (X7) (0.177). Annual income (X7) also showed an indirect pathway through land holding (X4) (0.172), and area under soybean crop (X5) showed an indirect pathway through land holding (X4) (0.166). Material possession (X8), social participation (X9) and innovativeness (X12) also showed their second substantial indirect pathways through annual income. Education (X2), extension contact (X10) and attitude towards BBF technology (X15) showed their second substantial indirect pathways through area under soybean crop, while economic motivation (X13) and risk orientation (X14) showed pathways through sources of information (X11). These results demonstrate that the socio-economic impact of BBF technology was associated with a combination of farm resources, economic conditions, information access and farmers' attitudes.

Overall, the path analysis showed that land holding, annual income, area under soybean crop, area under BBF technology, sources of information and attitude towards BBF technology had relatively important effects within the specified path model. The findings further show that several characteristics operated through indirect pathways, indicating the interconnected role of farm resources, economic conditions, information access and farmers' attitudes in relation to the socio-economic impact of BBF technology among soybean growers.

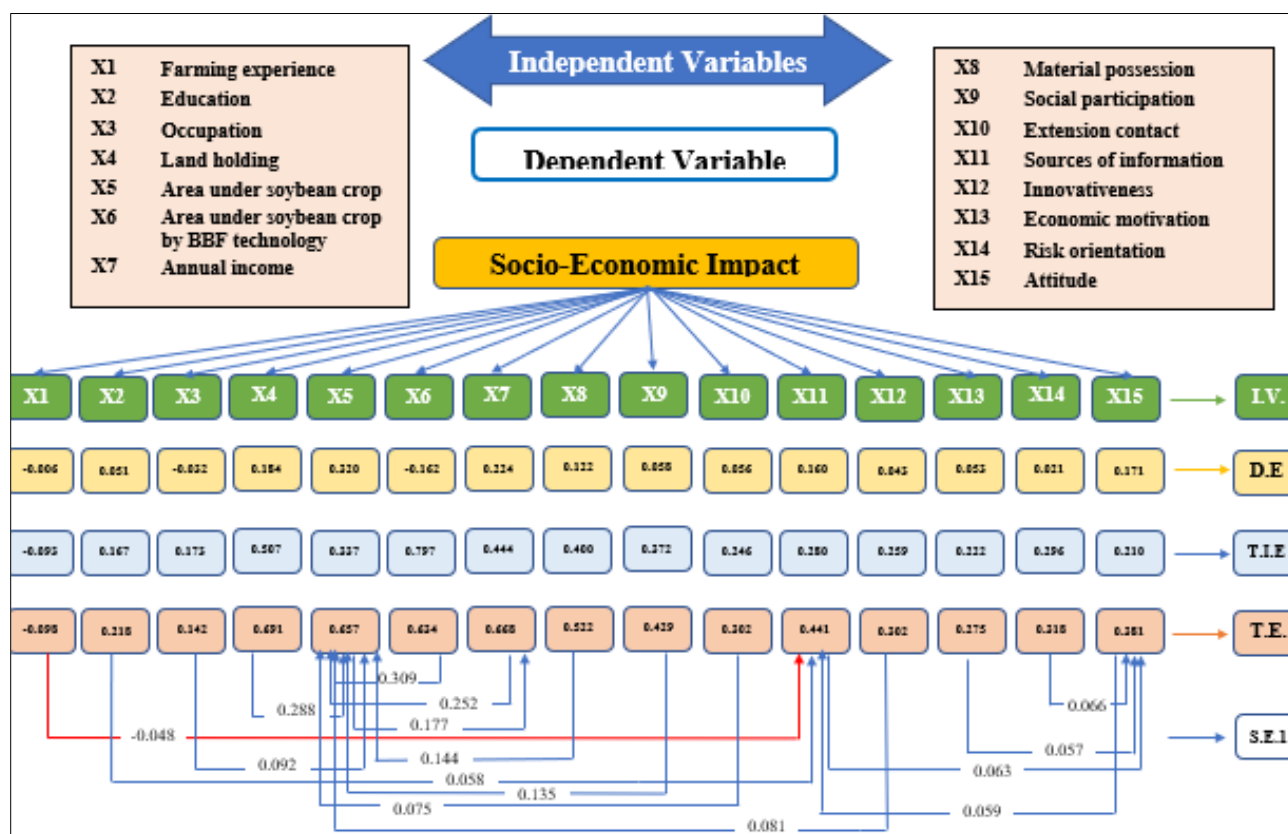


Fig 1: Path Analysis showing effect of profile of the BBF adopters with socio-economic impact of climate smart technology-broad bed furrow

Conclusion

The study revealed that the socio-economic impact of Broad Bed Furrow (BBF) technology among soybean growers was influenced by a combination of farm resources, economic conditions, information access and farmers attitudes. Among the selected characteristics, land holding recorded the highest total effect, followed by annual income, area under soybean crop and area under BBF technology. Area under soybean crop showed the highest positive direct effect, whereas area under BBF technology recorded a negative direct effect but a substantial positive indirect effect, indicating the importance of indirect pathways in explaining its overall contribution. The analysis further showed that area under soybean crop, sources of information and attitude towards BBF technology served as important pathways through which several characteristics contributed to the socio-economic impact. Overall, the findings highlight that the benefits associated with BBF technology are not influenced by a single characteristic but are linked with the combined effects and interrelationships among farmers' resource base, economic position, information access and attitude. Strengthening access to relevant information, encouraging favourable attitudes towards BBF and supporting farmers in effective management of farm resources may help enhance the socio-economic benefits associated with BBF technology among soybean growers in the study area.

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